

Having described the preferred embodiments, the invention is now claimed to be:

1. A magnetic resonance imaging scanner having a magnetic field gradient system including:

a magnetic field gradient coil (20);

a magnetic field gradient amplifier (30) operatively communicating with the magnetic field gradient coil (20); and

a pre-emphasis digital circuit (36) that receives a digital magnetic field gradient control signal and outputs pre-emphasis correction terms, the pre-emphasis digital circuit including:

a delay circuit (92) that delays the digital magnetic field gradient control signal by a selected time interval to produce a delayed digital magnetic field gradient control signal,

a plurality of digital filters (110) each having selected time constant and amplitude parameters, the digital filters (110) receiving the delayed digital magnetic field gradient control signal and outputting the pre-emphasis correction terms, and

a parameters memory (114) that stores at least the time constant and amplitude parameters of the digital filters (110).

2. The magnetic resonance imaging scanner as set forth in claim 1, wherein the pre-emphasis digital circuit (36) is integrated with electronics of the magnetic field gradient amplifier (30).

3. The magnetic resonance imaging scanner as set forth in claim 1, wherein the pre-emphasis digital circuit (36) further includes:

a second delay circuit (94) that delays a second digital magnetic field gradient control signal by a second selected time interval to produce a second delayed digital magnetic field gradient control signal; and

a multiplexor (108) that time domain multiplexes the delayed digital magnetic field gradient control signal and the second delayed digital magnetic field gradient control signal into the plurality of digital filters (110).

4. The magnetic resonance imaging scanner as set forth in claim 3, wherein the pre-emphasis digital circuit (36) further includes:

a destination selection circuit (120) that selectively combines the pre-emphasis correction terms with the delayed digital magnetic field gradient control signal and the second delayed digital magnetic field gradient control signal to produce a modified delayed digital magnetic field gradient control signal and a modified second delayed digital magnetic field gradient control signal, respectively.

5. The magnetic resonance imaging scanner as set forth in claim 1, wherein the pre-emphasis digital circuit (36) further includes:

an adder circuit (150, 152) that additively combines the pre-emphasis correction terms and the delayed digital magnetic field gradient control signal, the output of the adder circuit (152) controlling the magnetic field gradient amplifier (30).

6. The magnetic resonance imaging scanner as set forth in claim 1, wherein the pre-emphasis digital circuit (36) further includes:

a plurality of destination selection circuits (150, 152, 154, 156, 158, 160, 164, 166) that selectively combine the pre-emphasis correction terms, the delayed digital magnetic field gradient control signal, and at least one other delayed digital magnetic field gradient control signal to compute a plurality of control signals (40X, 40Y, 40Z, 42) for controlling a plurality of coil amplifiers (30, 32).

7. The magnetic resonance imaging scanner as set forth in claim 1, wherein the pre-emphasis digital circuit (36) further includes:

a high-pass filter (102) that filters the delayed digital magnetic field gradient control signal, the high-pass filtered delayed digital magnetic field gradient control signal being input to the digital filters (110).

8. The magnetic resonance imaging scanner as set forth in claim 7, wherein the high pass filter (102) is a delta filter.

9. The magnetic resonance imaging scanner as set forth in claim 1, wherein the delay circuit (92) includes:

a first-in, first-out (FIFO) buffer (92) having a buffer length corresponding to the selected time interval.

10. The magnetic resonance imaging scanner as set forth in claim 1, wherein the plurality of digital filters (110) are first-order digital filters that include:

an exponential decay calculator (130) that computes an exponential decay value based on the delayed digital magnetic field gradient control signal; and

a subtractor (136) that subtracts the exponential decay value from the delayed digital magnetic field gradient control signal.

11. The magnetic resonance imaging scanner as set forth in claim 10, wherein the exponential decay calculator (130) includes:

a multiplier (132); and

a bit shifter (134);

the multiplier (132) and the bit shifter (134) cooperatively computing the exponential decay value.

12. The magnetic resonance imaging scanner as set forth in claim 10, wherein the plurality of first-order digital filters (110) further include:

a scaling circuit (140) that scales an amplitude of the subtractor output.

13. The magnetic resonance imaging scanner as set forth in claim 12, wherein the scaling circuit (140) includes:

an amplitude multiplier (142); and

an amplitude bit shifter (144);

the amplitude multiplier (142) and the amplitude bit shifter (144) cooperatively effecting the amplitude scaling.

14. The magnetic resonance imaging scanner as set forth in claim 1, further including:

a shim coil (22);

a shim coil amplifier (32) operatively communicating with the shim coil (22); and

a destination selection circuit (164, 166) that selectively applies the pre-emphasis correction terms to the shim coil amplifier (32).

15. The magnetic resonance imaging scanner as set forth in claim 1, wherein the digital magnetic field gradient control signal has a first sample rate, and a portion of the pre-emphasis digital circuit (36) operates at a second sample rate that is less than the first sample rate, the pre-emphasis digital circuit (36) further including:

an interpolator (70) that combines samples of the digital magnetic field gradient control signal and outputs an interpolated control signal with the second sample rate.

16. The magnetic resonance imaging scanner as set forth in claim 15, wherein the first sample rate is an integer N times larger than the second sample rate, and interpolator (70) includes:
an accumulator (72) that accumulates N samples to compute the interpolated control signal.

17. In a magnetic resonance imaging apparatus, a pre-emphasis digital circuit (36) for computing pre-emphasis correction terms for a digital magnetic field gradient control signal, the pre-emphasis digital circuit (36) including:

a means (92) for delaying the digital magnetic field gradient control signal by a selected time interval to produce a delayed digital magnetic field gradient control signal;

a means (110) for digitally filtering the delayed digital magnetic field gradient control signal, the filtering means (110) implementing plurality of filters each having selected time constant and amplitude parameters, the filtering means (110) receiving the delayed digital magnetic field gradient control signal and outputting the pre-emphasis correction terms; and

a parameters memory means (114) for storing at least the time constant and amplitude parameters of the digital filtering means (110).

18. The pre-emphasis digital circuit (36) as set forth in claim 17, wherein the digital magnetic field gradient control signal includes at least two digital magnetic field gradient control signals, the delay means (92, 94) produces a plurality of delayed digital magnetic field gradient control signals corresponding to the at least two digital magnetic field gradient control signals, and the pre-emphasis digital circuit (36) further includes:

a multiplexing means (108) for selectably inputting the plurality of delayed digital magnetic field gradient control signals to the filtering means (110) to produce the pre-emphasis correction terms; and

a selecting means (120) for selectably applying the pre-emphasis correction terms to selected magnetic field-generating means (20, 22).

19. The pre-emphasis digital circuit (36) as set forth in claim 17, wherein the delay means (92) includes:

a synchronous digital storage means (92) for storing each sample of the digital magnetic field gradient control signal for a selected number of clock cycles corresponding to selected time interval, after which the synchronous digital storage means (92) outputs the sample.

20. The pre-emphasis digital circuit (36) as set forth in claim 19, wherein the synchronous digital storage means (92) includes a first in, first out circuit.

21. The pre-emphasis digital circuit (36) as set forth in claim 17, wherein the digital filtering means (110) implements first order digital filters, the digital filtering means (110) including:

an exponential decay means (130, 136) for effecting an exponential decay of the delayed digital magnetic field gradient control signal; and

an amplitude scaling means (140) for effecting an amplitude scaling of the delayed digital magnetic field gradient control signal.

22. A method for controlling a magnetic field-generating coil (20, 22) of a magnetic resonance imaging scanner (10), the method including:

delaying a digital magnetic field gradient control signal by a selected time interval to produce a delayed digital magnetic field gradient control signal;

digitally filtering the delayed digital magnetic field gradient control signal;

constructing at least one coil control signal based on the delayed digital magnetic field gradient control signal and the digitally filtered delayed digital magnetic field gradient control signal; and

controlling a magnetic field coil amplifier (30, 32) of the magnetic resonance imaging scanner (10) using the coil control signal, the magnetic field coil amplifier (30, 32) energizing the magnetic field-generating coil (20, 22) based on the coil control signal.

23. The method as set forth in claim 22, wherein the delaying includes:

storing each sample of the digital magnetic field gradient control signal in a clocked memory (92); and

releasing the stored sample from the clocked memory (92) after a number of clock cycles selected to correspond to the selected time interval.

24. The method as set forth in claim 22, wherein the delaying includes:

passing the digital magnetic field gradient control signal through a clocked first in, first out (FIFO) buffer (92) having a buffer length corresponding to the selected time interval.

25. The method as set forth in claim 22, wherein the digital filtering includes:

multiplying each sample of the delayed digital magnetic field gradient control signal by an exponential factor to produce a subtractive decay portion; and

subtracting the subtractive decay portion from the delayed digital magnetic field gradient control signal.

26. The method as set forth in claim 25, wherein the multiplying by an exponential factor includes:

multiplying the sample by an integer to produce an intermediate value; and

bit-shifting one of the sample and the intermediate value by a selected number of bit positions to effect a division by a power of 2.

27. The method as set forth in claim 22, further including:

digitally interpolating the digital magnetic field gradient control signal at a first clock rate to produce an interpolated digital magnetic field gradient control signal at a second clock rate that is slower than the first clock rate; and

performing the delaying and the digital filtering on the interpolated digital magnetic field gradient control signal at the second clock rate.

28. The method as set forth in claim 22, wherein the controlling of a magnetic field coil amplifier (30, 32) of the magnetic resonance imaging scanner (10) using the coil control signal includes:

applying the coil control signal to a shim coil amplifier (32).